

A century later: Rediscovery and range expansion of *Typhlocaris lethaea* Parisi, 1920 (Crustacea, Decapoda) in subterranean karstic waters of Benghazi, northeastern Libya

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Academic editor: Fabio Stoch | Received 26 January 2025 | Accepted 2 February 2025 | Published 4 March 2025

<https://zoobank.org/5AC0B5D7-13A8-41CC-86F3-81B4156561ED>

Citation: Ruggieri R, Elbaraasi H, Al Riaydh MH, Elshaafi A, Bilal A, Salloum F, Abdelmalik M (2025) A century later: Rediscovery and range expansion of *Typhlocaris lethaea* Parisi, 1920 (Crustacea, Decapoda) in subterranean karstic waters of Benghazi, northeastern Libya. Subterranean Biology 51: 21–29. <https://doi.org/10.3897/subtbiol.51.147950>

Abstract

This study confirms the existence of the blind cave shrimp *Typhlocaris lethaea* Parisi, 1920, in Lethe Cave, Benghazi, Libya, nearly a century after its initial discovery, and documents its new distribution in the Al-Coeffiah caves. Field surveys conducted in 2023 and 2024 revealed its presence in the El-Khadim and Al-Jebah caves, extending its known range by 9 km. Specimens were found in subterranean lakes characterized by complete darkness, with water parameters including an average temperature of 22 °C, pH of 7.67, and salinity of 4.72 ppt. Two specimens were used for further analysis. These findings suggest that the species is more widespread than previously thought and highlight the potential hydrological connections within the karstic system. Additionally, the discovery of a depigmented isopod in El-Khadim cave suggests further hidden biodiversity. Given its IUCN data-deficient status, our findings emphasize the need for conservation efforts to protect these fragile ecosystems from human impacts, ensuring the preservation of Libya's unique subterranean biodiversity.

Keywords

Biospeleology, cave ecosystems, conservation biology, Libya, stygobiotic shrimp

Introduction

The subterranean ecosystem and its biodiversity are generally unfamiliar to the public, particularly to individuals without specialized knowledge of underground biology (Marmonier et al. 2023). A similar situation exists in the Benghazi Plain, north-eastern Libya. This area is heavily karstified by an intricate network of subterranean lakes and conduits. This is because of its geological setting, which is primarily composed of carbonate rocks of the Benghazi Formation (Salloum et al. 2022; El-Rayani et al. 2024). These conduits are mostly associated with the Bou-Atni and Al-Coeffiah areas east of Benghazi. The stygobiotic shrimp genus *Typhlocaris* (Calman 1909) (Malacostraca: Decapoda: Typhlocarididae) is exclusively located in the subterranean water habitats of the Mediterranean region (Turnamal 2008). All species exhibited stygomorphism, being characterized by the complete absence of eyes and pigmentation throughout the body. Additionally, they are distinguished by the presence of a longitudinal post-antennal suture, a structural characteristic that can be observed on the lateral surfaces of their carapaces (Bauer 2004; De Grave et al. 2008; De Grave and Fransen 2011; Guy-Haim et al. 2018). Currently, four valid species of this genus are known from four locations in the Mediterranean Sea (Fig. 1). Each location is inhabited by a distinct species with no congeners in the open sea. Two species are known from the eastern coastline of the Mediterranean Sea: *T. galilea* (Calman 1909) from the Tabgha spring and *T. ayyaloni* (Turnamal 2008), discovered in a huge and natural network of pits known as Ayyalon cave, approximately 120 km south of Tabgha. The third species, *T. salentina* (Caroli 1923), was described from the Zinzulusa cave in southern Italy and was recently discovered in two other caves (Froglia and Ungaro 2001). The fourth species, *T. lethaea* Parisi, 1920, was known from the Lethe (also known as Al Jekh) cave in Benghazi, Libya. Vito Zanan was the first ever to notice this decapod in the Lethe cave. He sent this to Bruno Parisi, who attributed it to *T. galilea*. Subsequently, Parisi sent one specimen to William Thomas Calman at the British Museum. After comparing it with the types of *T. galilea*, Calman concluded that it was a distinct species. After careful examination, Parisi described it under the name *T. lethaea* (Parisi 1920).

Unfortunately, the species was not reported in subsequent literature, and even Guy-Haim et al. (2018), in their molecular revision of the genus *Typhlocaris*, were unable to obtain any specimens of *T. lethaea*. For this reason, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species classifies this species as data-deficient (De Grave 2013). Therefore, this short communication discusses the confirmation of the existence of the Lethe cave blind shrimp, *T. lethaea*, for the first time since 1920, and documents a novel and typical distribution of this species within the Al-Coeffiah caves in the Benghazi plain, Libya.

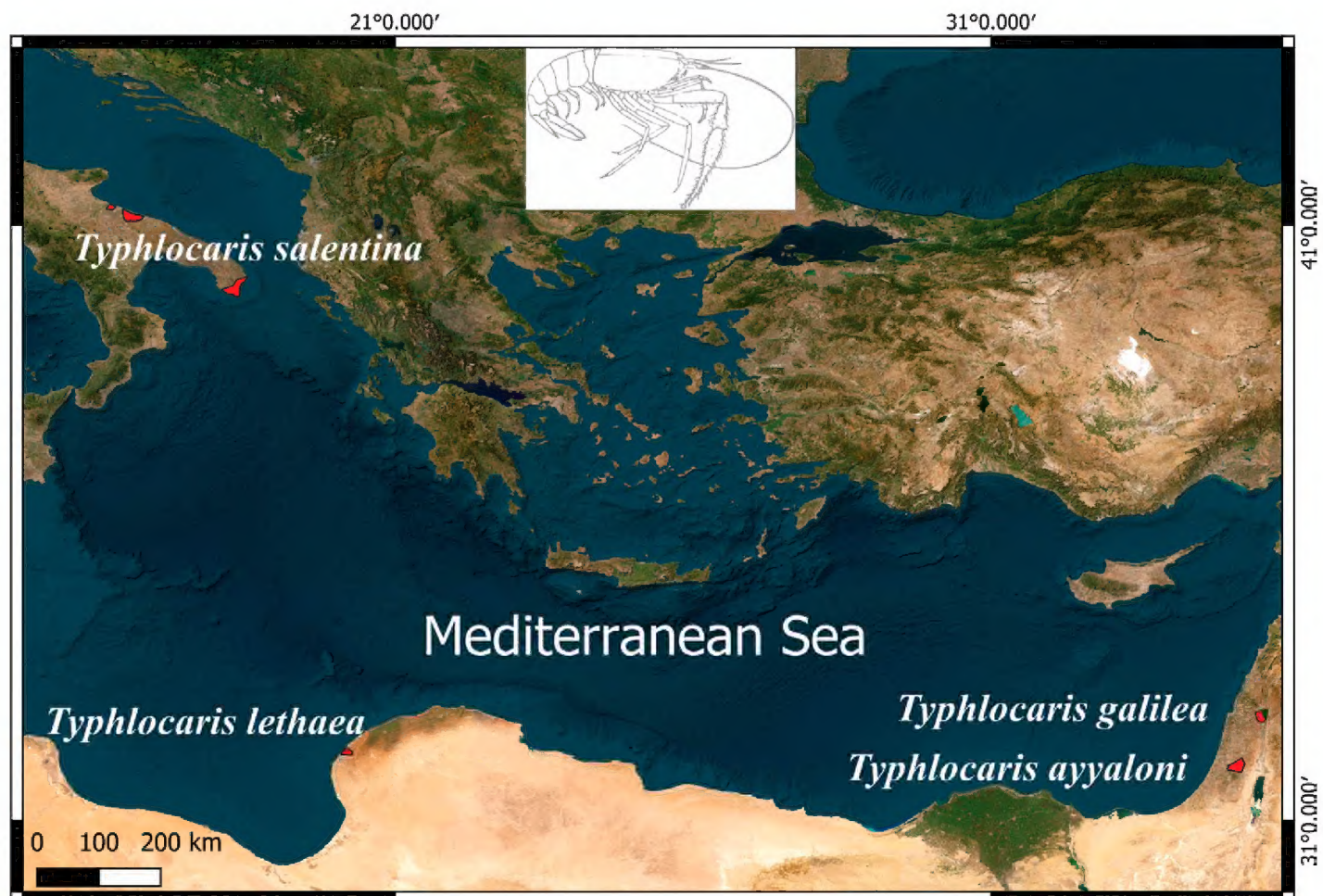


Figure 1. Distribution map of four *Typhlocaris* species from four locations around the Mediterranean Sea, modified after De Grave and Fransen (2011).

Materials and methods

Lethe cave

This cave is located in Bou-Atni area, south of Benghazi city, Libya, with coordinates 32°06'58.16"N, 20°09'24.44"E and an altitude of 30 m a.s.l. The cave was explored and surveyed by a research group from Centro Ibleo di Ricerche Speleo-Idrogeologiche di Ragusa, Italy (CIRS), and the Earth Science Department at the University of Benghazi (Benghazi, Libya) in 2007 and 2009. The cave is a part of several collapsed dolines lined up in NE – SW direction (Ruggieri and Abdelmalik 2009; Ruggieri 2010; Ruggieri et al. 2025), and the cave itself can be divided into two main branches. During the initial exploration of the Lethe cave in January 2007, several specimens (3-6 individuals) of genus *Typhlocaris*, likely belonging to the species *T. lethaea*, were observed on the sandy muddy bottom of the first branch of the subterranean lake, which is nourished by an underground aquifer of brackish water (Ruggieri and Abdelmalik 2009; Ruggieri 2010; Ruggieri et al. 2025). The specimens were located in dark sections a few meters from the platform landing stage. Given the clarity of the water, we were able to film and photograph one of them (Fig. 2A).

Al-Coeffiah caves

In 2023, two field visits were conducted in the Al-Coeffiah area northeast of Benghazi. Al-Coeffiah suburban's covers a surface area of about 835 km² and it is largely affected by many karstic features including caves and various sizes of dolines with complex

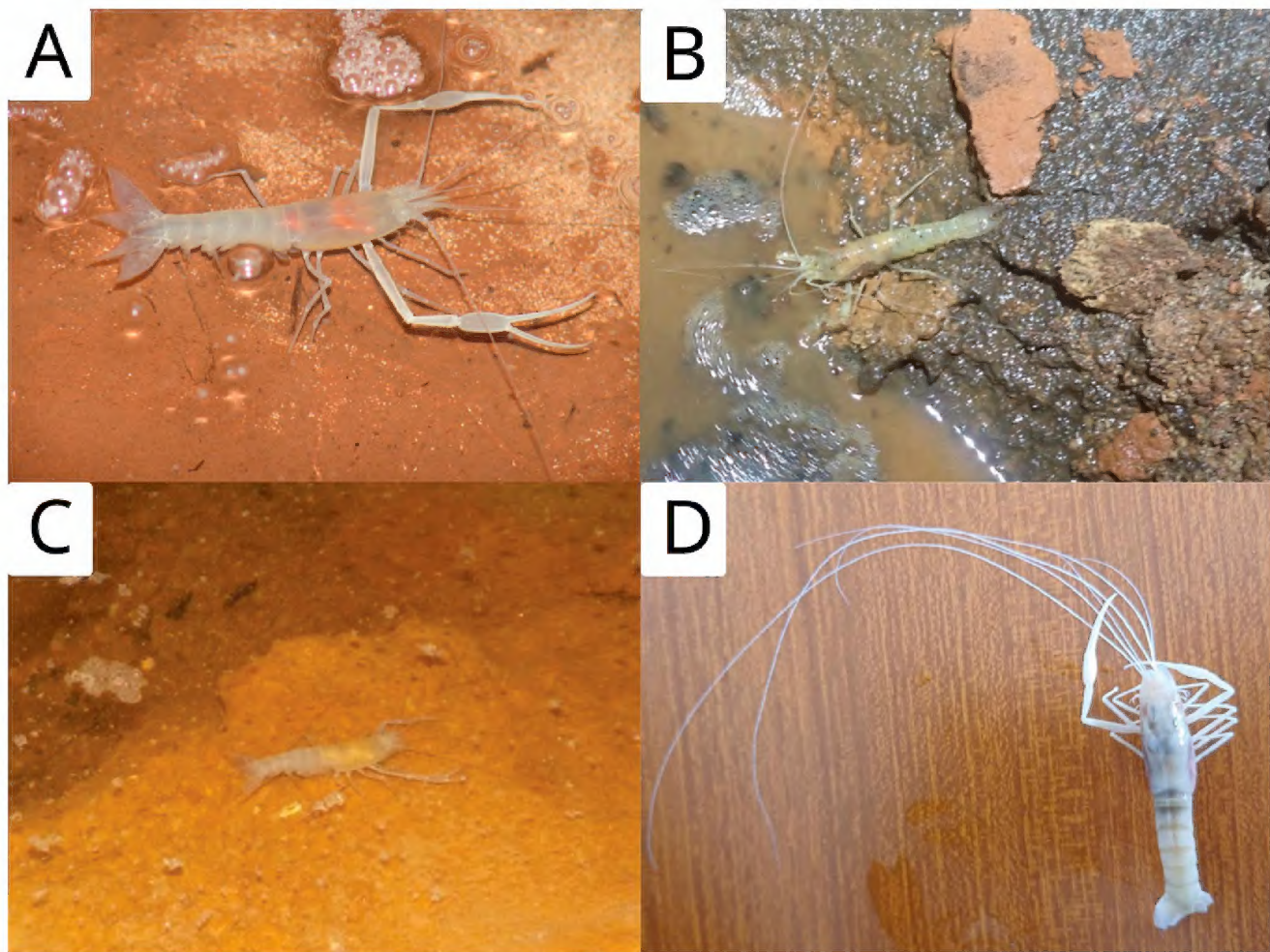


Figure 2. The rediscovered cave-dwelling shrimp *T. lethaea* during the survey of different caves in Bou-Atni and Al-Coeffiah areas, Benghazi plain, NE, Libya **A** *T. lethaea* observed on 2007 during the initial visit to the Lethe cave in Bou-Atni area (Photo by Iolanda Galletti) **B** *T. lethaea* reported on July 2023 during the exploration of the El-Khadim cave in Al-Coeffiah area (Photo by Rosario Ruggieri) **C** the same species reported on October 2023 during the exploration of the Al-Jebah cave in Al-Coeffiah area (Photo by Giovanni Gianninoto) **D** one of the two specimens collected during a recent visit to the El-Khadim cave, on the December 7th, 2024 (Photo by Houssein Elbaraasi).

underground drainage systems (Elshaafi et al. 2021; Salloum et al. 2022; El-Rayani et al. 2024). On July 2023 during a visit to explore El-Khadim doline-cave, which is located approximately 15 km northeast of Benghazi Port, at 32°11'50"N, 20°11'16"E, with an altitude of 21 m a.s.l (Fig. 3), a single specimen of *T. lethaea* was discovered and is reported here for the first time as a new record (Fig. 2B). The specimen was laid on a rocky muddy surface a few centimeters out of the water. Furthermore, during the above-mentioned exploration, an isopod measuring a few millimeters in size and completely white was observed in the same cave. On October 2023, during the exploration visit of the Al-Jebah collapse-doline cave at 32°11'59"N, 20°10'57"E, with an altitude of 21 m a.s.l, which is also located within Al-Coeffiah area, a single specimen of *T. lethaea* was observed again on muddy bottom of the cave (Fig. 2C).

Specimens collection

Recently, a group of researchers from the Departments of Zoology and Earth Sciences from the University of Benghazi conducted a second exploration visit to El-Khadim cave on December 7, 2024. The main aim of this study was to confirm the new

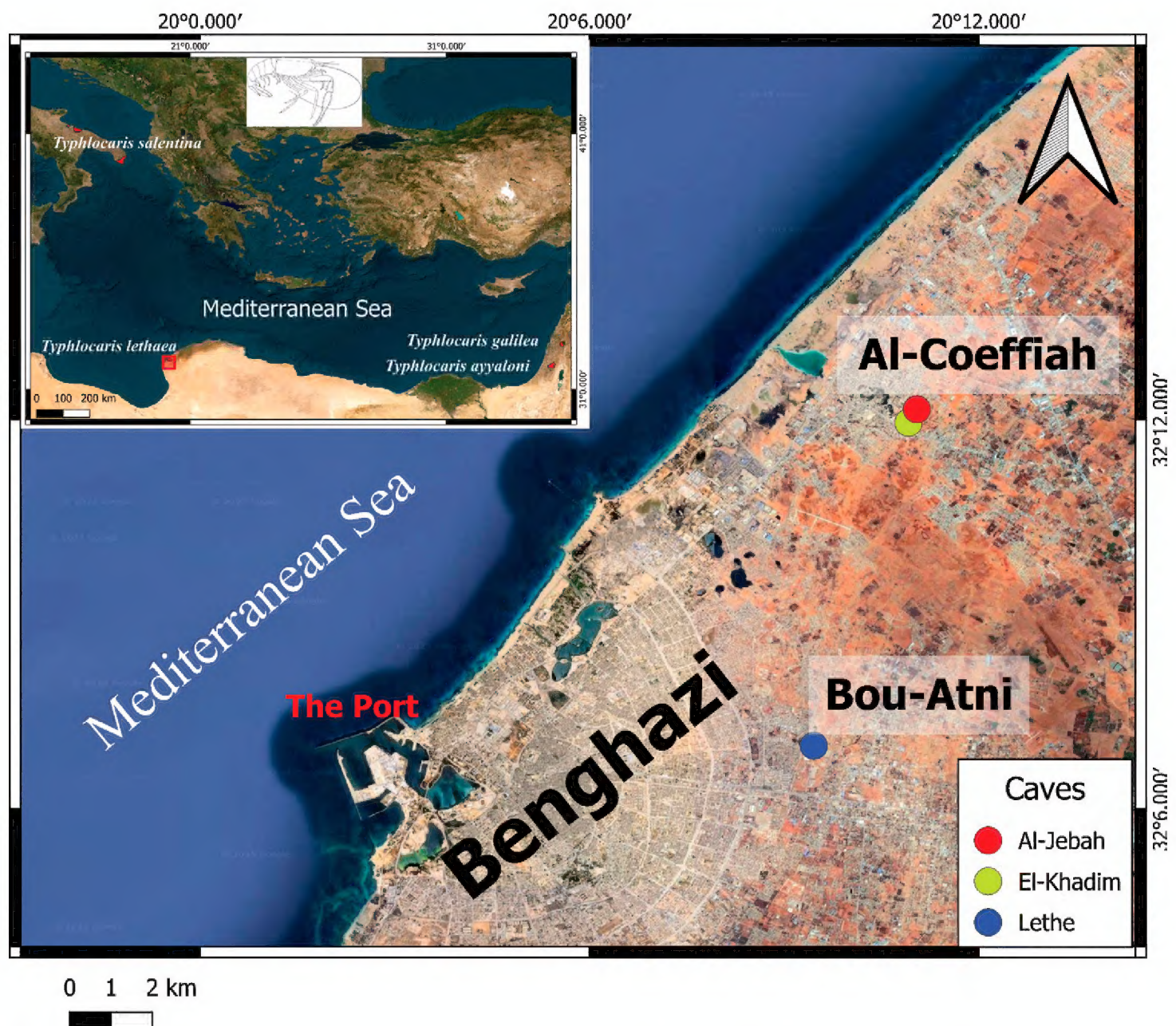


Figure 3. New records of *T. lethaea* based on field observations during the exploration of caves in the Bou-Atni area in 2007, and 2023 and 2024 in the Al-Coeffiah area.

distribution and collect samples of this species. Two specimens were collected using a dip net from the surface of the first subterranean lake, stored in 96% ethanol, and transferred to the Department of Zoology at the University of Benghazi for further investigation (Fig. 2D, Suppl. material 1). Water temperature, air temperature, pH, and salinity in the cave were measured to better understand shrimp habitats.

Results and discussion

Research on biodiversity and organisms in caves in Libya, specifically in Benghazi, has not yet been undertaken, resulting in a significant scientific gap regarding subterranean organisms. The Libyan blind shrimp *T. lethaea* is Benghazi's only endemic cave species to the south of the Mediterranean Basin. Information on this has been scarce since Parisi discovered it in the mysterious Lethe cave in 1920, leading to a widespread belief that it was extinct in its infancy. This paper presents for the first time, after almost 100 years, the confirmation of the existence of the stygobi-

ont species *T. lethaea* in Lethe cave and documents a new and unusual distribution in the newly explored El-Khadim cave and Al-Jebah cave in the Al-Coeffiah area, Benghazi. Libya. Our attempts to collect and confirm the presence of this decapod were successful. Although our visit was brief, this species was observed several times, indicating that its populations were abundant, particularly in the cave systems of the Al-Coeffiah area.

Caves are commonly characterized by a very special environment with complete darkness, high humidity, and low temperature fluctuations (De Grave & Fransen, 2011). The documented *T. lethaea* are commonly found to inhabit sandy and muddy bottoms on the surface of water mixed with organic debris and rocks. All our observations of this decapod Crustacean occurred in sections of caves characterized by complete darkness, such as *T. lethaea* reported from the El-Khadim and Al-Jebah caves (Al-Coeffiah area), and this is in good agreement with the conditions described in the original discovery in Lethe cave (Parisi, 1920). In this study, the average water and air temperatures were 22 and 21 °C, respectively. Average pH was 7.67. The average salinity of the water was 4.72 ppt. The two specimens collected from El-Khadim cave in 2024 were female, with a total length of 5 cm.

This study reports unusual findings for *T. lethaea* from a new area near Benghazi, and this new location extends the range of the species 9 km north of the original site in Benghazi (Bou-Atni) into the Al-Coeffiah area, 4 km southwest of the Mediterranean Sea coast (Fig. 3). The new record reported here, in combination with the detection of this species at a previously inventoried site (Lethe cave), suggests that this species is widely distributed in the subterranean waters of the karstic system of the Benghazi plain. We present a new record from a cave in Benghazi, expanding the range of *T. lethaea* to encompass much of the Benghazi area and altering its extinction risk status owing to the inclusion of this new locality.

Our records suggest that the hydrological systems of the Lethe caves (Bou-Atni area), El-Khadim and Al-Jebah caves (Al-Coeffiah area) are somehow interconnected, as both habitats harbor the same species of stygobiotic shrimp, *T. lethaea*, which is commonly observed. Furthermore, some biospeleological methods that study the DNA of subterranean stygobiotic animals and enable the establishment of biogeographic connections between underground watercourses should be used in conjunction with traditional hydrogeological methods to connect caves (Marin 2020; Marin and Turbanov 2021). This method can be applied in future research based on our findings, as well as other stygobiotic animals that may be prevalent in subterranean watercourses.

Existing knowledge on Libyan cave biodiversity has never been the focus of any research, and this study is considered a spark to open new areas for future research and scientific interest. Our observations in the studied caves and earlier observations from the same area are the only investigations of possible biodiversity in cave environments in Libya. Future research should fill the gaps in cave biology and ecology by potentially increasing the number of species and answering fundamental questions related to the biodiversity and health of underground populations.

Conclusions

The karstic underground system of Benghazi is unique because of its caves and fauna, which host aquatic and terrestrial cave-restricted species associated with subterranean aquifers and several cases of endemism. It is well known that the *Typhlocaris* species are classified as endangered and are listed in the IUCN Red List. The caves in which they live are not designated as protected areas or legally protected, and some caves have already been affected by human activity. Efforts must be made to engage local stakeholders in conservation actions to protect these unique cave ecosystems and the biological communities inhabiting them. Furthermore, this karst area remains outside the protected zones and is exposed to high groundwater pumping and pollution. Our findings confirm the existence of *T. lethaea* in Lethe cave, and the new unusual distribution in the Al-Coeffiah caves highlights the value of subterranean biodiversity, which increases its ecological significance and biological uniqueness, reinforcing its importance in conservation efforts. In addition, the biodiversity present in the karst system of the Benghazi plain may be further enriched by the discovery of a completely depigmented isopod, which was observed during the exploration of El-Khadim cave in July 2023. This species was not collected because of the absence of appropriate sampling equipment.

Acknowledgments

This work represents a contribution to the Cyrenaica Karst Project, an international cooperation between the Department of Earth Sciences at the University of Benghazi and the Hyblean Center of Speleo-Hydrogeological Research (CIRS), Italy. We are indebted to the University of Benghazi for logistical support, El-Diqa Lab for water chemical analysis from El-Khadim cave, and Mr. Jammal Alkomaty for his immense assistance during cave visits. Finally, we thank the Editor-in-Chief of Subterranean Biology, Fabio Stoch, for his valuable comments that improved this manuscript.

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Supplementary material I

Movie

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Data type: multimedia

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